Typically, 90 to 120 decibels are generated by the Indiana ANG's current air-to-ground gunnery range operations. Note that less than 65 decibels is considered an acceptable level of noise. However, since the cessation of the JPG's firing mission in September 1994, impulse noise impacts beyond the base boundaries have been eliminated. The only remaining noise zone identified at JPG is an aerial track used by aircraft at the air-to-ground gunnery range located in the northwestern section of the installation.

There is no noise generated in the DU Impact Area. There are no activities in the cantonment area that would generate noise above acceptable levels.

2.10 PUBLIC AND OCCUPATIONAL HEALTH

Information on sources and levels of background radiation and current sources of radioactive material is presented in Section 3.1 of this report. The potential human exposures to DU are presented in the DP and summarized in Sections 5 and 6 of this ER.

Major sources of chemical exposure, addressed in Section 3.2 of this ER, are confined to the cantonment area of the installation. Additional information on these sources and expected levels of exposure are contained in the RI (MWH 2002).

2.11 TRANSPORTATION

JPG includes 196 miles of improved roads, 22 bridges, and 10 low-water crossings. Improved roadways of concrete or asphalt surface total 34 miles (55 km), and gravel-surfaced roads constitute the remainder of the road network. There also are some unimproved roads on the installation. Most of the roads are in good condition. All roads in the cantonment are paved. Sections at low-water crossings of the West Perimeter Road, East Perimeter Road, and a section of K Road east of Machine Gun Road are the only paved roads in the test range area (U.S. Army 1995b). Under the MOA (Appendix A), the USAF and FWS share responsibilities for infrastructure maintenance north of the firing line.

Three interstate highways are near JPG. Interstate 65, running north–south, is 30 miles (48 km) to the west. Interstate 74, running east–west, is 40 miles (64 km) north of JPG. Access to the installation is via Route 421, a two-lane road following the eastern border of the installation.

Prior to closure in 1995, JPG had a railway system and airfield. The airfield is presently closed and the rail system was transferred to the Madison Port Authority under the BRAC program. The Madison Railroad, a Division of City of Madison Port Authority, is a 25-mile (40-km) shortline operating from Madison to North Vernon, Indiana. The railroad acquired an engine house, 17 miles (27 km) of trackage, and a loading dock located on JPG. As a result of this acquisition, the railroad now offers transloading and car storage (see http://jpg.sbccom.army.mil/).

2.12 VISUAL/SCENIC RESOURCES

JPG is divided visually into the areas north and south of the firing line. The area south of the firing line, or cantonment areas, is a well-maintained area with buildings that formerly supported the installation staff. The main gate entrance is flanked by well-manicured grounds and tree-lined, open spaces that provide a visually attractive entrance to the facility. The road to the administrative area is lined with mature maple trees. The buildings in these areas are predominantly wood structures. Operations and maintenance buildings are red brick and were heated by steam through an aboveground steam system

when the facility was operational. Thirteen housing units are arranged along a tree-lined, elongated, horseshoe-shaped drive. Other visual resources include Krueger Lake, approximately 1,200 ft (366 m) long by 250 ft (76 m) wide. A closed airfield occupies the southwestern area of the base (U.S. Army 1995b). The remaining area includes woodlands and grassy areas. A dominant feature in this area is a water tower. With closure of this area in 1995, the property was transferred. Various parcels are under private or public ownership. Residential, light manufacturing operations, and farming are the predominant land uses currently (see http://jpg.sbccom.army.mil/).

The area north of the firing line is characterized as heavily vegetated rolling hills, with some open spaces. The DU Impact Area and the ANG bombing range are located within this portion of JPG (see Figure 1-1). Appendix B includes photographs of the cantonment and DU Impact Areas from different directions.

There are several landfill/disposal and open burning/open detonation areas dispersed in this area north of the firing line (see Section 2.12). In the northeast corner of the base is a 165-acre (0.67-m^2) lake (Old Timbers Lake) used for fishing. Archaeological structures are present in this area and include six structures and four stone bridges (see Section 2.7). Large floodgates were installed for security reasons at stream exit locations along the base's western fence line. More than 48 miles (77 km) of chain-link fence topped with barbed wire surrounds the facility. The view of the facility from the fence line is obscured primarily by trees 30 to 50 ft (9 to 15 m) tall with thin undergrowth. Occasional open spaces around the fence line permit views of up to several hundred yards.

The Bureau of Land Management (BLM) Visual Resource Inventory and Evaluation System rating for the DU Impact Area is Class I. The rating for the cantonment area is Class IV. Refer to Appendix C for more information on the visual resource inventory.

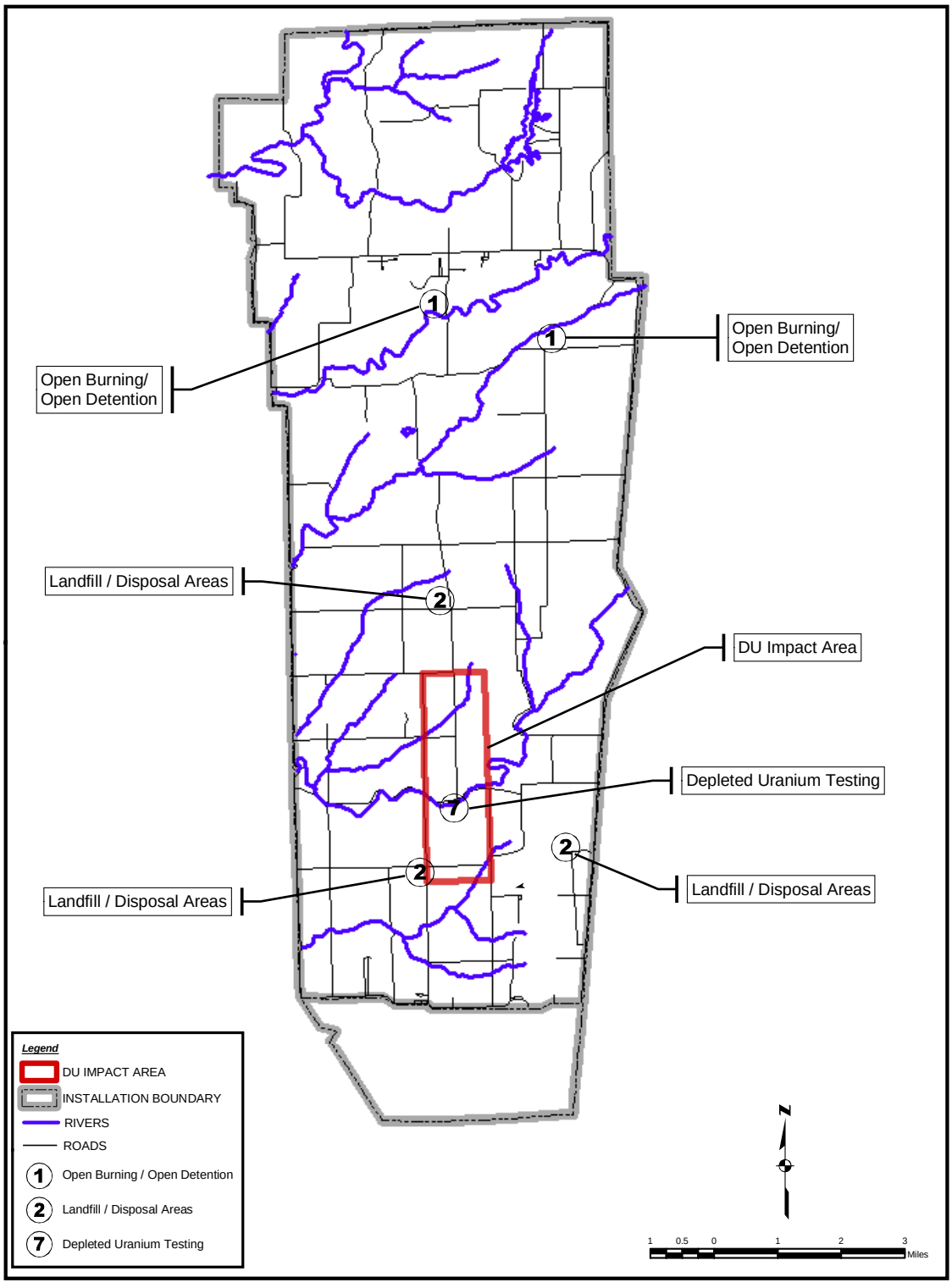
2.13 WASTE MANAGEMENT

Prior to closure in 1995, JPG generated and managed hazardous waste from munitions testing activities [e.g., scrap propellant and scrap High Explosives (HE) projectiles], hazardous waste from installation maintenance and support activities (e.g., spent solvents, paint, and photo finishing chemicals), and miscellaneous solid waste (e.g., packaging materials, construction rubble, and sanitary wastewater). The locations of these operations and related disposal areas occurred throughout the installation. Figure 2-13 indicates the locations of related activities in the area north of the firing line where the DU Impact Area is located. In addition, the RI in the cantonment area (MWH 2002) assesses 50 sites, which were for potential contamination releases as a result of mission operations (see Section 3.2.2).

As a result of its munitions testing mission, OE[1] remains at JPG. The types, quantities, and probable locations of ordnance items utilized by the U.S. Department of Defense (DOD) at JPG were identified in an Archive Search Report (USACE 1995). Information contained in this report is based on the review of existing documents, interviews, observations, site-specific geology, aerial photography, and descriptions of known or suspected contamination. The probable and known locations of OE are reflected in Figure 1-1.

The DU Impact Area contains approximately 154,323 pounds (70,000 kg) of DU varying in size from microscopic particles to complete penetrators. This DU remains as a result of DU penetrator testing from 1983 to 1994. Approximately 66,139 pounds (30,000 kg) of the 220,462 pounds (100,000 kg) fired were

[1]Ordnance and explosives (OE) is ammunition, ammunition components, chemical or biological warfare materiel, or explosives that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried, or fired. Unexploded ordnance (UXO), a subcategory of OE, refers to military munitions that have been primed, fuzed, or otherwise prepared for action, and have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard and remain unexploded.



Source: SAIC 1997a.

Figure 2-13. Location of Past Hazardous Substance Activities North of the Firing Line

retrieved and disposed, leaving the remaining 154,323 pounds (70,000 kg) of DU. Additional information on DU, which is based on the scoping and characterization surveys (SEG 1995, 1996), is provided in Section 3.1.

3.0 NATURE AND EXTENT OF CONTAMINATION

Both radiological and non-radiological investigations have been completed at JPG. Section 3.1 summarizes the radiological investigations conducted at the DU Impact Area. Section 3.2 summarizes the non-radiological investigations that have focused primarily on the area south of the firing line. Data supporting radiological characterization of the site are based on SEG scoping and characterization surveys (SEG 1995, 1996). Characterizations south of the firing line are based on the Draft Final RI (MWH 2002).

3.1 RADIOLOGICAL STATUS

In this section the status of radiological contamination in the DU Impact Area is summarized (Sections 3.1.2 and 3.1.3). This discussion is preceded by an overview of DU (Section 3.1.1). Section 3.1.4 summarizes anticipated impacts from implementation of the FWS's FMP, which will impact the DU Impact Area. The DP (U.S. Army 2002b) includes additional information related to the radiological status of the facility.

3.1.1 Introduction

DU results from the enrichment of natural uranium for use in nuclear reactors and nuclear weapons. It is defined as uranium that has less than 0.711% of the isotope uranium-235. DU consists principally of uranium-238, with trace amounts of uranium-235. Although 0.7 times as radioactive as natural uranium, DU metal is pyrophoric (able to ignite spontaneously) and extremely dense (Ebinger et al. 1996). DOD Military Specifications require that DU must have 0.335% or less uranium-235, and DU actually used by DOD has only 0.2% uranium-235. When manufactured as 30 millimeter (mm) DU rounds, each DU projectile contains approximately 0.3 kg of extruded DU, alloyed with 0.754% by weight titanium. The projectile is encased in a 0.8 mm-thick aluminum shell as the final DU round (Lockheed Martin 1995).

Natural uranium is a slightly radioactive metal that is present in most rocks and soils as well as in many rivers and sea water. Natural uranium primarily consists of a mixture of two isotopes of uranium, uranium-235 and uranium-238, in the proportion of about 0.7 and 99.3%, respectively.

The average background radiation dose normally received by an individual is about 360 millirems (mrem) per year. A mrem is a measurement unit that expresses the amount of absorbed dose from a radiation source that has a biological effect on human tissue. Millirem per hour or year expresses the rate at which a person may receive this dose when directly exposed to the source. Uranium accounts for approximately 4% of the average annual background radiation dose received by individuals. Background radiation doses are the result of naturally occurring uranium; radionuclides in air and water, such as radon; and water, cosmic radiation, and other common sources, such as medical and dental X-rays and consumer products (Gollnick 1994). Additionally, less than one mrem per year is the result of fall-out from past atmospheric nuclear weapons testing.

Potential threats to human health from DU are radioactivity and toxic chemical hazards, with the chemical hazards posing the highest risk (Davis 1990). If inhaled in soluble form, compounds of DU can cause chemical toxicity to the kidney. Radioactive dangers are less for compounds of DU than for natural uranium. One gram of natural uranium emits 0.68 microcurie (μCi) of radiation, while DU emits 0.36 μCi of radiation per gram. This difference is due most to removal of radioactive products during the enrichment processes that produce DU (Davis 1990).

The U.S. Army has completed several studies on the health and environmental effects of DU use in both peacetime training operations at Yuma Proving Ground, Arizona; Aberdeen Proving Ground, Maryland; and battlefield operations in the Persian Gulf. These studies generally involve differences in the modes in which DU firing occurs and in the potential exposure of personnel to DU during these operations. The Army's use of DU includes a variety of caliber applications in the M1 and M60 series tanks, the Bradley Fighting Vehicle, and Armored Guns System in ground-firing activities. Related operations present a greater potential for ground disturbance and personnel exposure to DU particulates than firing DU from fixed positions or from aircraft where personnel are not present. Relevant conclusions from these studies are cited in this ER where appropriate. It is recognized that additional studies are needed to more fully define current DU health and environmental effects (USAF 2002).

3.1.2 Regional Background Radiation

A background study was performed in 1995 to determine site background levels prior to conducting measurements in the DU Impact Area. Thirty-five background measurements were taken south of the firing line in an unaffected area. An average background value of 12 microroentgen per hour (μR/hr) was established for this area consistent with background levels determined in 1983. Background values ranged from 6 to 8 μR/hr on roads and in creek beds to a high of 10 to 12 μR/hr in open fields and wooded areas (SEG 1995).

3.1.3 DU Impact Area

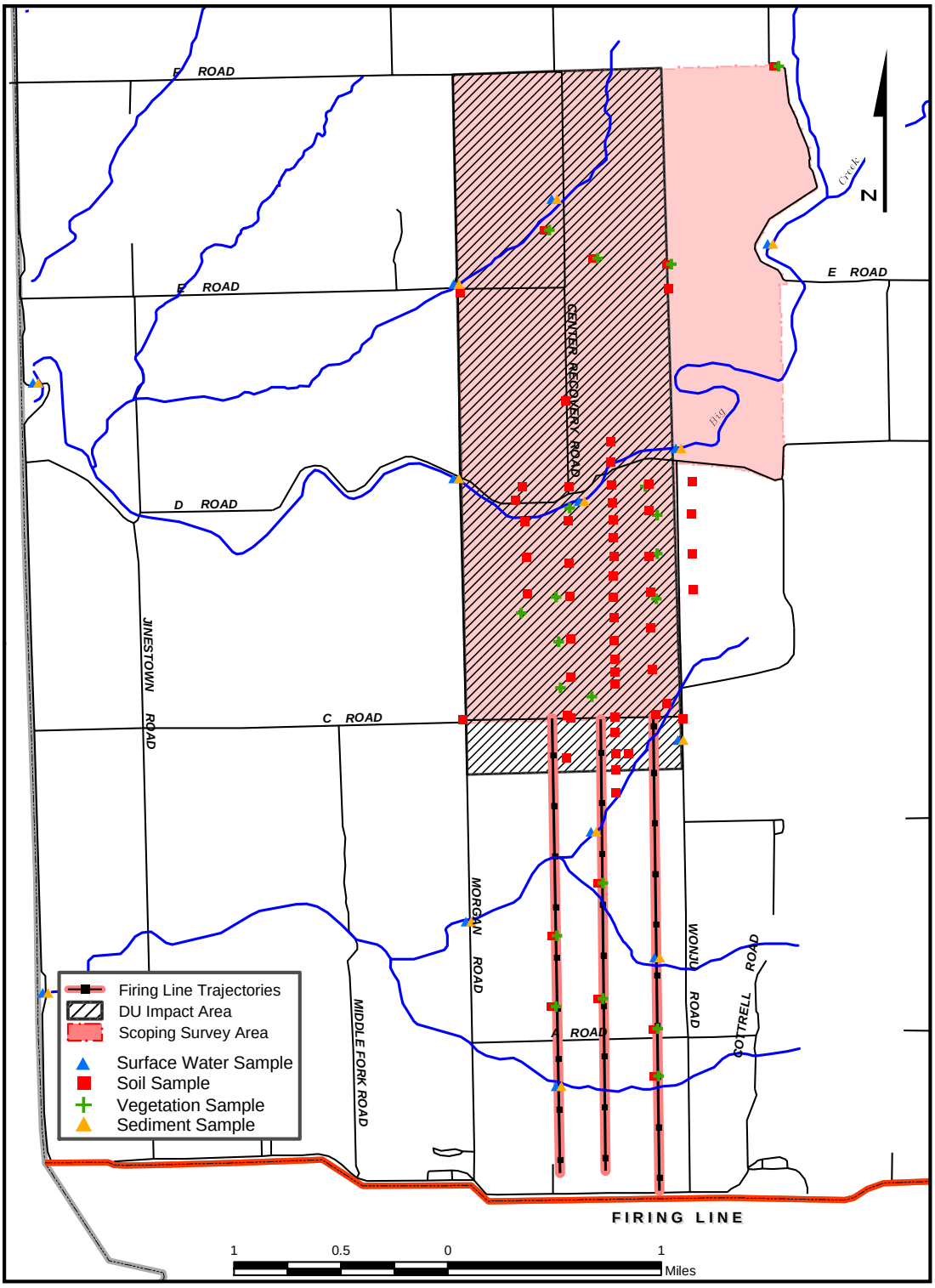
A scoping survey was conducted in 1995 (SEG 1995) to determine the boundaries of the DU Impact Area. This survey evaluated areas located to the north and east of the DU Impact Area as well as radiation surveys along the three affected trajectories from the firing line. A characterization survey (SEG 1996) of the DU Impact Area was conducted to confirm the amount and extent of activity in the area. The results of these investigations are discussed in this section.

A scoping survey conducted in 1994 identified and delineated the affected portion of the DU Impact Area. The survey included gamma radiation measurements and environmental sampling (soil, groundwater, surface water, sediment, and vegetation samples) [SEG 1995]. The impacted area was defined as that area that contained radioactivity in excess of 35 picocuries per gram (pCi/g) of DU in soil. A characterization survey was conducted in 1995 to confirm and document the amount and extent of radioactivity in the DU Impact Area to estimate remedial costs, waste volumes, and techniques for decontamination of the area (SEG 1996). The findings of the SEG surveys are consistent with the results from the annual environmental monitoring program.

3.1.3.1 Scoping Survey Results

The scoping survey consisted of a radiation survey of the DU Impact Area, a radiation survey of the trajectories from the firing line into the DU Impact Area, and environmental sampling and analysis (Figure 3-1). Samples of all media were obtained both within and exterior to the 2,080-acre (8.4-km^2) DU Impact Area. Collection methods and locations were similar to those used for the environmental monitoring program (SEG 1995).

The radiation survey of the DU Impact Area was based on an unbiased, gridded survey with grid lines established at intervals of 164 ft (50 m) from north to south on the eastern and western boundaries (SEG 1995). Radiation measurements were collected 3.3 ft (1 m) from the ground every 32.8 ft (10 m) along the grid line. The Ludlum Model 3250 Data Logger™ and the Ludlum Model 44-2™ sodium iodide (NaI) detector were used for the exposure rate surveys. The radiation survey of the firing lines was performed



Source: SEG 1995.

Figure 3-1. Scoping Survey Sample Locations
Jefferson Proving Ground, Indiana

similarly to the impact area survey except that the grid lines ran south to north from the firing points to C Road (Figure 3-1). Three grids were established along the trajectory from the firing point: one down the center of the trajectory path, one 164 ft (50 m) east, and one 164 ft (50 m) west. Measurements were collected at intervals of 32.8 ft (10 m) along each grid.

Soil, groundwater, surface water, sediment, and vegetation samples were collected prior to the radiation survey. These samples were collected in accordance with approved SEG procedures and shipped to an approved off-site laboratory for analysis (SEG 1995) [see Figure 3-2]. Volume 2 of SEG (1995) provides details on the survey plan and SEG procedures. The procedures identify survey instrumentation requirements, measurement and sample collection procedures, data quality objectives, and data reduction and evaluation methods. Table 3-1 summarizes the soil sampling results from the scoping survey. Details of the results by sample number for each medium sampled are provided in the SEG report (SEG 1995).

Table 3-1. Scoping Survey Sample Results

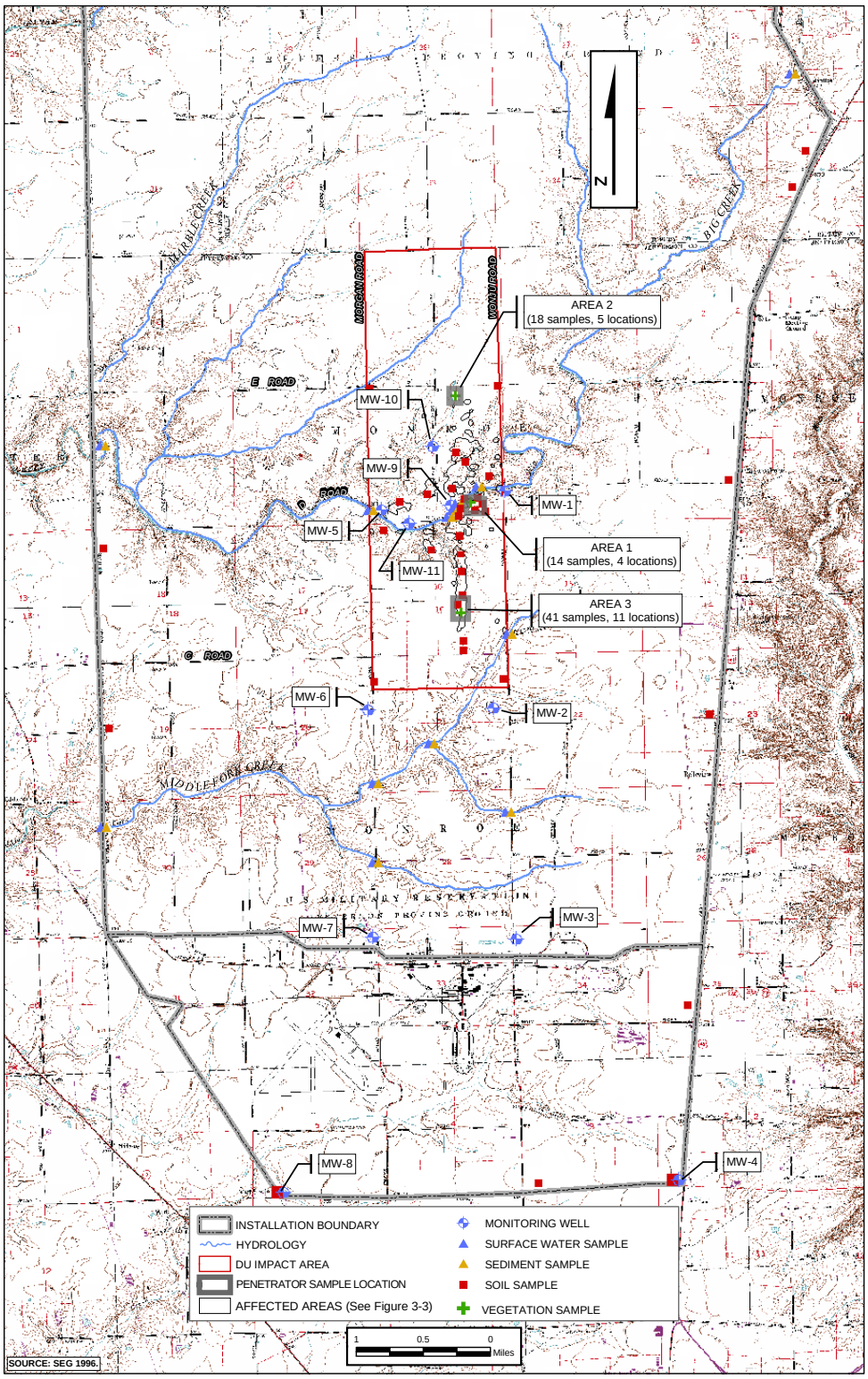
Sample Location	No. of Samples	Total Uranium Range in Concentration
DU Impact Area and Environs		
Soil	50	1.35–201 pCi/g
Sediment	11	0.42–1.9 pCi/g
Surface Water	12	0.21–3.6 pCi/L
Vegetation	14	0.01–0.50 pCi/g
Trajectory Locations		
Soil	12	1.42–1.87 pCi/g
Sediment	2	2.03–3.08 pCi/g
Surface Water	2	0.35–0.88 pCi/L
Groundwater	11	0.43–3.6 pCi/L
Vegetation	6	0.06–0.65 pCi/g

Source: Compiled from SEG 1995.
DU = depleted uranium.
pCi/L = picocuries per liter.
pCi/g = picocuries per gram.

Soil Samples—Sixty-two soil samples were collected during the scoping survey. Fifty samples were collected from within the DU Impact Area, and 12 samples were collected along the 3 trajectories between the firing line and C Road (Figure 3-1). The soil sampling program was unbiased and based on a 492-ft (150-m) grid system. Samples were collected along the 500 center firing position, along lines parallel to and 984 ft (300 m) east and west of the 500 center firing position, and along lines 1,968 ft (600 m) east and west, respectively, of the 500 center firing position. Each sample was collected to a depth of approximately 0.5 in (1.27 cm).

Soil samples were analyzed by Quanterra Environmental Services Richland Laboratory for radiochemical analyses. The samples were analyzed using alpha spectroscopy for uranium (U)-234, -235, and -238 by method ITAS-RD-323A.

The results of this sampling indicated that the highest uranium concentrations were detected south of Big Creek within the DU Impact Area. Total uranium concentrations ranged from <1.3 to 201 pCi/g, with an average concentration of 12.9 pCi/g. Soil samples collected along the trajectories south of the DU Impact Area had concentrations ranging from 1.4 to 1.8 pCi/g of total uranium.



Source: SEG 1996.

Figure 3-2. Characterization Survey Sample Locations
Jefferson Proving Ground, Indiana

Soil samples were analyzed for concentrations of the three major uranium isotopes: U-234, U-235, and U-238. The U-238 to U-234 activity ratio (unitless) was reviewed to determine whether the uranium is naturally occurring or includes DU. In samples containing naturally occurring uranium, the activity ratio of U-238 to U-234 is approximately 1 (0.5 to 1.3). The activity ratio for DU is 5.5 to 9 based on a review of isotopic analysis of penetrators collected from the field within the DU Impact Area (SEG 1995). Therefore, environmental measurements with U-238 to U-234 activity ratios greater than two are indicative of DU contamination.

The scoping survey soil samples indicated evidence of DU contamination primarily along the central and eastern trajectories within the DU Impact Area.

***Sediment Samples*—**Sediment samples were collected at the same locations where surface water samples were obtained during the scoping survey. The total uranium concentration in sediment samples ranged from 0.88 to 1.09 pCi/g within the DU Impact Area. Along the firing line trajectories, the total uranium concentration in sediment was measured at 2 and 3 pCi/g along two different streams south of the DU Impact Area. The U-238 to U-234 activity ratio in the sediment samples collected during the scoping survey indicates that the uranium is naturally occurring.

***Surface Water Samples*—**Fourteen surface water samples were collected during the scoping survey using the same methods described above for soil sampling. Eight samples were collected from the DU Impact Area and environs, and six samples were collected from the firing line trajectories in the vicinity of Middle Fork Creek. Near the DU Impact Area, three samples were collected upstream along Big Fork Creek; two samples were collected from within the DU Impact Area; one sample was collected from Big Creek, downstream of the DU Impact Area; and the remaining two samples were collected from streams that flow into Big Creek.

The firing line trajectories were sampled at six locations: a sampling point located upstream of the firing line trajectories along Middle Fork Creek, one sampling point that coincided with a firing line trajectory, two downstream sampling locations, and two sampling points along streams that flow into Middle Fork Creek.

The total uranium concentrations in surface water that flowed through the DU Impact Area ranged from 0.21 to 4.11 pCi/L. The uranium concentration in surface water samples collected from streams intersecting the trajectories south of the firing line ranged from 1.42 to 1.87 pCi/L. The U-238 to U-234 activity ratio in the surface water samples collected during the scoping survey ranged from 0.35 to 1.0, indicating that the uranium is naturally occurring.

***Groundwater Samples*—**Total uranium ranged from 0.43 to 3.609 pCi/L in 11 groundwater samples. These levels were well below the guideline level of 15 pCi/L. There was no indication of contamination when background concentration was subtracted.

***Vegetation Samples*—**Twenty vegetation samples were collected during the scoping survey using the same methods for soil sampling. Fourteen samples were obtained from within the DU Impact Area, and six samples were obtained along the firing line trajectories. The total uranium concentration in vegetation samples was less than 0.7 pCi/g in all samples. Two lichen samples from the south-central portion of the DU Impact Area had U-238 to U-234 activity ratios of 2.3 and 2.6, which indicate DU contamination.

3.1.3.2 Characterization Survey Results

The characterization survey included the collection of exposure rate and in situ gamma spectroscopy measurements and soil, groundwater, surface water, sediment, vegetation, and biological samples. Background sampling was completed for surface and subsurface soil (10 locations), groundwater

(6 locations), surface water (3 locations), and sediment (3 locations). All samples were analyzed by alpha spectroscopy for U-234, U-235, and U-238 by Lockheed Analytical Laboratories. The isotopic uranium analysis was performed using Standard Operating Procedure (SOP) No. LAL-91-SOP-0108 (SEG 1996). Figure 3-2 shows the sampling locations for environmental media collected in support of site characterization. Soil sample results from the characterization survey are provided in Table 3-2.

Table 3-2. Soil Characterization Survey Results

Depth (cm) BGS	No. of Samples	Total Uranium Range in Concentration (pCi/g)	Average (pCi/g)
Background			
0–15	10	1.52–2.53	1.97
15–30	10	1.33–2.59	1.84
30–45	10	1.33–2.76	1.95
Penetrator Soil Samples			
0–15	20	2.9–12,318	2,881
15–30	20	1.5–547	79.5
30–45	20	1.8–63	12.7
45–60	13	1.4–11.5	4.50
Random Soil Samples			
0–15	20	1.46–4.73	2.60
15–30	20	1.51–6.91	2.40
30–45	20	1.34–4.21	2.00

Source: Compiled from SEG 1996.
BGS = below ground surface.
cm = centimeter.
pCi/g = picocuries per gram.

Soil Samples—Background surface and subsurface soil samples were collected from 10 sites in areas not impacted by the DU testing. Soil sample results from the characterization survey are provided in Table 3-2. The background locations were selected to ensure that these locations were representative of the different types of soils in the impact area and consistent with those locations sampled in 1983 as part of the baseline environmental impact survey. Background soil samples were collected from three depths at each location: 0 to 5.9 in. (0 to 15 cm), 5.9 to 11.8 in. (15 to 30 cm), and 11.8 to 17.7 in. (30 to 45 cm) below BGS. Total uranium concentrations ranged from 1.33 to 2.76 pCi/g in the background soil samples (see Table 3-2). The U-238 to U-234 activity ratio in the background soil samples ranged from 0.5 to 1.3.

Both random soil and penetrator soil samples were collected in support of the site characterization program. Surface and subsurface soil samples also were collected from 20 randomly selected locations in the impacted area (SEG 1996). Surface and subsurface soil samples were collected directly under penetrators or penetrator fragments. Twenty locations were identified within three areas where the penetrators or fragments were at the surface. The random soil sampling locations and the three penetrator sampling locations are shown on Figure 3-2.

Penetrator Soil Samples—Sixty soil samples were collected beneath 20 penetrators. The total uranium concentrations ranged from 1.5 pCi/g at a depth of 11.8 to 17.7 in. (30 to 45 cm) BGS to 12,318 pCi/g at a depth of 0 to 5.9 in. (0 to 15 cm) BGS in Area 3 (Figure 3-2). The uranium concentration decreased with depth as indicated in Table 3-2. At a depth from the surface to 5.9 in. (15 cm) BGS, the average concentration was 2,881 pCi/g of total uranium (Table 3-2). At a depth from 11.8 to 17.7 in. (30 to 45 cm) BGS, the average concentration of total uranium was 12.7 pCi/g. At a depth from 17.7 to 23.6 in. (45 to 60 cm) BGS, the average concentration of total uranium was 4.5 pCi/g. The U-238 to U-234 activity ratio

in the penetrator soil samples indicated DU contamination to depths of 11.9 in. (30 cm) BGS at some locations and to depths of 23.6 in. (60 cm) BGS at others.

Random Soil Samples—Sixty soil samples also were collected from 20 randomly selected locations within the impact area. None of the samples was from trenches within the DU Impact Area. The total uranium concentrations ranged from 1.34 to 6.91 pCi/g, with an average concentration of 2.33 pCi/g. Most samples were at background concentrations. The U-238 to U-234 activity ratio in the random soil samples indicated that most of the uranium was naturally occurring.

The results of the soil sampling program indicate that soil contamination outside of the impact trenches is associated with proximity to penetrator fragments. Therefore, soil contamination that could result in doses above release criteria would be limited to either the primary impact trenches or areas containing penetrator fragments.

Surface Water and Sediment Samples—Surface water samples were collected from 10 stream locations within the impact area. The characterization survey results for the surface water, sediment, and vegetation samples are provided in Table 3-3. Six locations were sampled in Big Creek at locations both upstream and downstream of the DU Impact Area. Four locations in Middle Fork Creek were sampled. Upstream of the DU Impact Area at the site boundary, the total uranium concentration was measured at 0.62 pCi/L; at locations within the DU Impact Area, the total uranium concentration in surface water ranged from 0.77 to 25.02 pCi/L. At the sample location on the western boundary of the installation, the total uranium concentration in surface water measured 0.89 pCi/L. All samples were at or near background except for two sampling locations within the DU Impact Area. The surface water samples from the DU Impact Area that had higher total uranium concentrations were collected from static pools of water. The U-238 to U-234 activity ratio in the samples from static pools of water was 4.4 and 7.3, indicating the presence of DU contamination. The total uranium concentration in surface water samples collected from Middle Fork Creek ranged from 0.63 to 1.80 pCi/L.

Table 3-3. Characterization Survey Results for Surface Water, Sediment, and Vegetation

Environmental Media	No. of Samples	Total Uranium	
		Range in Concentration (pCi/g)	Average Concentration (pCi/g)
Surface Water	10	0.62–25.02	3.55
Sediment	10	0.75–6.20	2.5
Vegetation	10	17.0–3,447	627.5
Vegetation Root Wash	10	46.1–14,258	2,868.8

Source: Compiled from SEG 1996.
pCi/g = picocuries per gram.

Sediment samples were collected at the same locations as the surface water samples. At the Big Creek upstream location, the total uranium concentration in sediment was measured at 0.78 pCi/g. The total uranium concentration in sediment samples from within the DU Impact Area boundary ranged from 0.75 to 6.20 pCi/g. On the western boundary of the installation, the total uranium concentration was measured at 0.75 pCi/g. The sediment samples taken from static pools of water also had U-238 to U-234 activity ratios, indicating DU contamination.

Sediment samples collected from Middle Fork Creek had total uranium concentrations ranging from 1.81 to 3.46 pCi/g.

Vegetation Samples—Ten vegetation samples of lichens, leaves, or grasses were collected from the affected area trenches during site characterization. Samples were collected from the three penetrator fragment areas shown on Figure 3-2. Five vegetation samples were collected from Area 1, four samples from Area 2, and one sample from Area 3, and were analyzed for total uranium.

Samples were washed with deionized water prior to analysis, and the wash water was analyzed separately from the vegetation sample to determine the amount of uranium on the surface of, and in, the sample. The total uranium concentration in vegetation samples ranged from 0.75 to 3,447 pCi/g, with an average concentration of 627.5 pCi/g. The total uranium concentration in the root wash samples ranged from 46.1 to 14,258 pCi/g, with an average concentration of 2,869 pCi/g. The U-238 to U-234 activity ratio ranged from 6.1 to 8.4, indicating the presence of DU contamination.

Biological Samples—A total of eight biological samples were collected from deer, freshwater clams, fish, and a soft-shelled turtle. All of the biological samples from Big Creek were collected from the area adjacent to the DU Impact Area. The total uranium concentrations ranged from 0.091 pCi/g in deer liver to a maximum of 0.774 pCi/g in a freshwater clam. The results of the biological sampling are shown in Table 3-4. The U-238 to U-234 activity ratio ranged from 0.4 to 1.2 and does not indicate the presence of DU contamination.

Table 3-4. Biological Sample Results

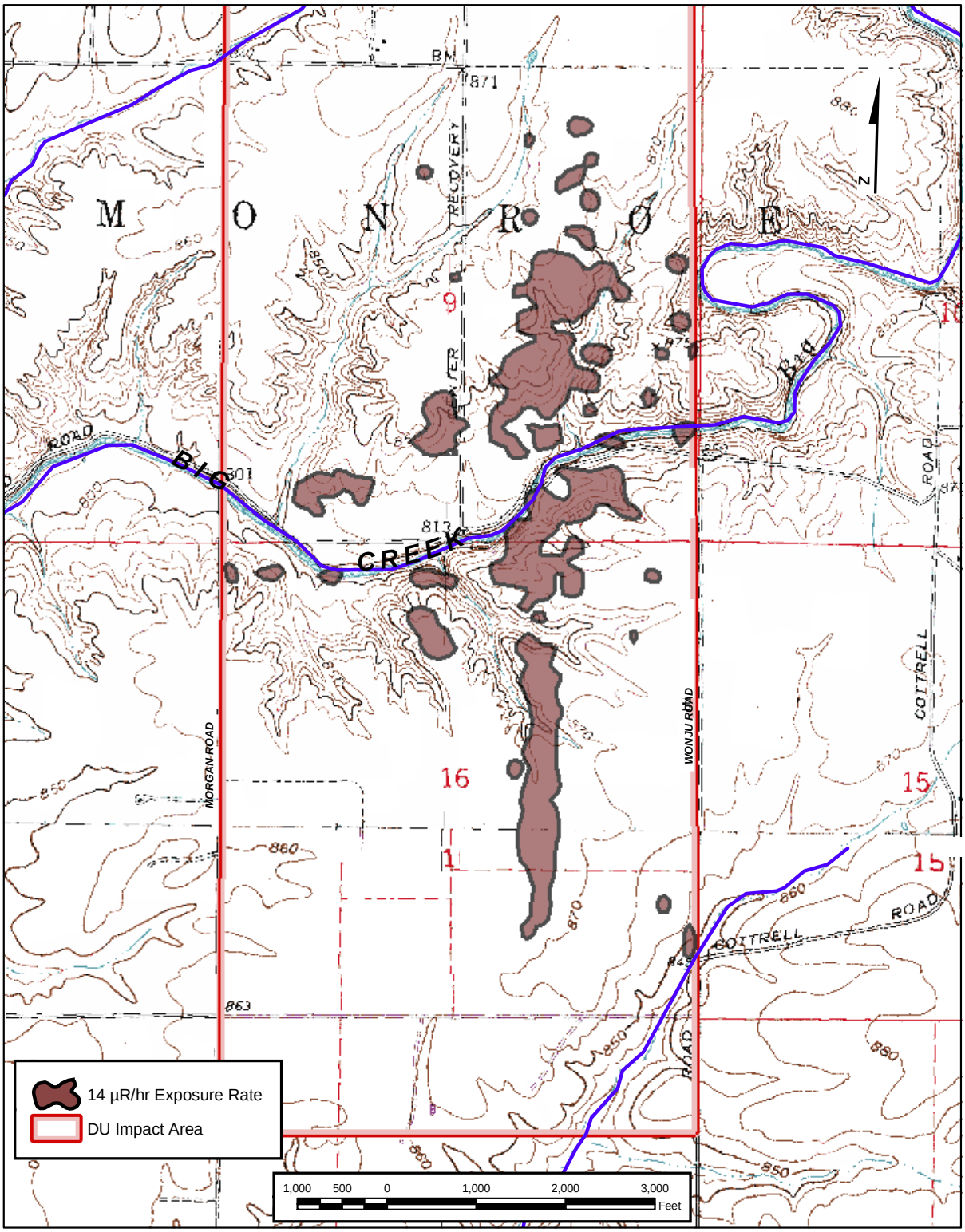
Sample Type	Total Uranium (pCi/g)
Deer Liver	0.091
Deer Kidney	0.151
Deer Bone	0.416
Freshwater Clams	0.774
Freshwater Clams	0.334
Fish	0.150
Fish	0.282
Soft Shelled Turtle	0.245

Source: Compiled from SEG 1996.
pCi/g = picocuries per gram.

Groundwater Samples—The total uranium concentration in groundwater samples collected as part of the site characterization program ranged from 0.33 to 5.09 pCi/L at background levels at the site. The U-238 to U-234 activity ratio in groundwater water samples indicates that the uranium is naturally occurring.

In situ Gamma Spectroscopy and Exposure Rate Measurements—To further define the affected area, the relationship between the average concentration of DU in the ground and exposure rate was analyzed to determine the isotopic concentration from the in situ gamma spectroscopy data. These measurements were obtained with the same instrument used in the scoping survey (SEG 1995).

At each location, a single in situ gamma spectroscopy measurement yielded the total inventory of activity for each nuclide presented as an area of activity concentration at the surface. Using these results, the concentrations of thorium-234 and polonium-234m were calculated for depth ranges of 0 to 5.9 in. (0 to 15 cm), 5.9 to 11.8 in. (15 to 30 cm), and 11.8 to 17.7 in. (30 to 45 cm) BGS. The specific assumptions used to determine this relationship are presented in SEG (1996). The exposure rate corresponding to a DU concentration of 35 pCi/g is 14.4 µR/hr. The contour map showing areas with an exposure rate greater than 14.4 µR/hr is shown in Figure 3-3.



Source: SEG 1996.

Figure 3-3. Exposure Rate of 14 µR/hr from Soil at Jefferson Proving Ground, Indiana

Based on the 35 pCi/g contour, SEG estimated the volume of DU contamination as 72,000 yd^3 (55,000 m^3). This value is based on an average depth of DU contamination of 4.3 in. (0.11 m) and an area of approximately 125 acres (500,000 m^2). This volume is an estimate of the total soil volume that would be removed; however, the depth of remediation is likely to be greater. In the vicinity of penetrators, the remediation depth could reach 18 in. (45 cm) [SEG 1996].

3.1.3.3 Annual Environmental Monitoring Program

An environmental monitoring plan was developed for the JPG DU Impact Area before the initial DU munitions were fired in 1984, and this plan guided sample collection and analysis through 1995. This sampling plan and protocol were updated in 1996 (U.S. Army 1996) and 2000 (U.S. Army 2000). Sampling locations for soils, surface water, and groundwater are shown in the environmental monitoring plan, and the sampling design for vegetation and biota are also presented. Samples were collected and analyzed semiannually for total uranium and, often, the isotopic composition of uranium in samples. The environmental sampling data are summarized for the 1984–1994 period (Ebinger and Hansen 1996). Soil concentration data for the DU Impact Area from 1984–2000 are skewed left with a mean value of 18.8 pCi/g and a median value of 1.5 pCi/g; the standard deviation of these samples is almost 200 pCi/g (Table 3-5). Of nearly 400 soil samples analyzed since 1984, most are less than 2 pCi/g, which is identical to the average background soil concentration of uranium at JPG. Similar distributions for DU concentrations in groundwater and surface water were obtained for the same period (Table 3-5). The environmental data indicate that the expected concentrations of uranium or DU are significantly less than the derived concentration guideline of 35 pCi/g for soil and 150 pCi/L for surface water and groundwater (U. S. Army 1996).

Table 3-5. Descriptive Statistics of DU concentrations in Soil, Groundwater, and Surface Water Samples (1984–2000)

	Soil (pCi/g)	Groundwater (pCi/L)	Surface Water (pCi/L)
Mean	18.8	2.7	1.6
Median	1.5	1.3	0.26
Standard Deviation	197.1	5.6	5.6
Minimum	-0.8	-0.1	-1.2
Maximum	3857	81.1	49
Number of Samples	388	365	312

Source: Ebinger and Hansen 1996.
pCi/g = picocuries per gram.
pCi/L = picocuries per liter.

As noted in Section 3.1.2, several monitoring wells were completed around the DU firing range between 1984 and 1994. These wells were bored to various depths that ranged to over 40 ft from the surface (SEC Donohue 1992). The groundwater data show some variation in the concentration of uranium in wells between 1984 and 2000, the largest of which was attributed to error in sample handling at the analytical laboratories (Ebinger and Hansen 1996). Overall, the data indicate that DU contamination has not moved to the groundwater or surface water from the DU Impact Area. This conclusion was further supported by the isotopic composition of uranium in the groundwater samples (Ebinger and Hansen 1996).

Surface water samples from monitoring locations on Big Creek upstream and downstream from the DU Impact Area varied in uranium and DU concentration during the 1984–2000 period, but there was neither long-term elevation of the concentration, nor sustained, elevated concentration at any sampling site. Some of the observed variation in surface water samples may be attributable to uranium incidentally being used as a trace constituent of phosphate fertilizer (Ebinger and Hansen 1996). Isotopic ratios of these samples indicate that most of the observed variation was due to a natural uranium in surface water and not DU.

The summary data suggest that the main source of uranium in surface waters is natural in origin, that is, from fertilizers or geologic deposits, which were transported via water or erosion. Whether from natural sources or agricultural fertilizer, the concentrations are well below the Army derived concentration guideline levels (DCGLs) [U.S. Army 1996] and low enough to be of little concern.

Vegetation and animal sampling also was conducted (Ebinger and Hansen 1996); however, the data set is not as complete as for the abiotic media. From the reported data there does not appear to be an adverse impact on the vegetation and animals. One lichen sample indicated a high concentration, probably from DU in resuspended soil collecting on the lichen surface. Deer samples and raccoon and freshwater clam tissue show little uranium, either natural or from DU, was found in the tissues.

3.1.4 FWS Fire Management Program's Impact on the Area North of the Firing Line

In support of its management responsibilities for the Big Oaks NWR, the FWS is implementing an FMP (FWS 2001d). The goals of this plan are to manage the use of fire to complement or augment other means of maintaining refuge habitat and reduce fuels in areas that may pose risks to human and natural resources. The Big Oaks NWR is subdivided into four fire management units, two of which include portions of the DU Impact Area (i.e., FMU-3 and FMU-4). The FWS recognizes the presence of both UXO and DU in the FMP and requires suppression activities to occur only on the boundary of the refuge.

Table 3-6 summarizes the environmental consequences anticipated from implementing the FMP.

Table 3-6. Summary of Environmental Consequences for Management Ignited Prescribed Fire and Management Response to Wildland Fire

Resource	Impacts
Soil and Water Resources	Minor short-term impacts from prescribed fires
Vegetation and Fuels	No change from the current condition is expected. A more natural landscape would result from natural wildland fires.
Wildlife	No immediate change from the current conditions. A more natural assemblage of species would result from natural wildland fires over time.
Endangered and Threatened Species	No change from the current condition. Prescribed burns would be designed to avoid direct impacts to *M. sodalis* (i.e., suppressing all fires between April 15 and September 15).
Cultural Resources	No change from the current condition.
Visual/Aesthetics/Air Shed	Periodic extreme fire events could cause impacts to visual/aesthetics/air shed.

Source: FWS 2001e.

The effects of burning efforts at the Big Oaks NWR and the combined effects on the environment of all burning and other sources of particulate matter and overall impacts to habitats throughout the region were assessed. Cumulative impacts of the implementation of this plan on air quality in Indiana were anticipated to be minimal. No area within the region is a nonattainment air quality area, and none is likely to be directly or indirectly affected to approaching a level of significance needing to be addressed.

No cumulative loss of early successional habitats or contiguous forest would result at the Big Oaks NWR or within the state or region from implementation of this FMP. This plan strives to maintain the 8,000 acres of grassland and 6,000 acres of other early successional habitats that currently exist within the Big Oaks NWR.

The FWS indicates the air quality impacts would be minimal. In addition, the EA notes that DU is not readily transported in smoke associated with burning of natural vegetation in an environment similar to that occurring at the Big Oaks NWR (Williams et al. 1998).

Williams et al. (1998) used atmospheric dispersion computer models to evaluate the potential for human health impacts from exposure to contaminants that could be dispersed by fires on testing ranges at Aberdeen Proving Ground. The screening-level assessment does not actually estimate actual human health risks. One of the contaminants present in soil and vegetation as a result of past operations was DU.

The computer plume model, FIREPLUME, was used to predict ground-level concentrations resulting from releases of hazardous materials from a forest fire. The primary fire scenario was represented by a 100-m line source of fire occurring in either 25 acres of forest or grassland. Three classes of meteorological stability were considered (Classes A, D, and E). Other assumptions used in the analysis were used to ensure conservatism of the results. The maximum release concentration for DU was 6.58×10^{-5} mg/m^3. This exposure level was four orders of magnitude lower than the non-carcinogenic air screening levels for an adult and child, 0.9 and 0.44 mg/m^3, respectively. The carcinogenic air screening level for DU was not calculated because it is known to be lower than the non-carcinogenic risk (Davis 1990).

3.2 NON-RADIOLOGICAL STATUS

Current and historical ordnance testing and other environmental investigations at JPG are discussed in this section. The historical ordnance testing that has been conducted north of the firing line at the site is discussed in Section 3.2.1. Other environmental investigations being conducted south of the firing line are discussed in Section 3.2.2. Recent environmental investigations have included both installation-wide and site-specific studies. Investigations have focused on the extent of soil and groundwater contamination at potentially contaminated sites in the cantonment area.

The JPG mission was primarily to plan and conduct production acceptance tests, reconditioning tests, surveillance tests, and other studies of ammunition and weapons systems. Activities involved with this mission included detonation, burning, and disposal of many types of waste propellants, explosives, and pyrotechnic substances at the facility.

Ordnance testing operations at JPG were initiated in May 1941. JPG's mission was to test all types of ordnance: ammunition, projectiles, propellants, cartridge cases, primers, fuses, boosters, bombs, and grenades. The Army estimates that from World War II until base closure, 23 million rounds of ammunition were tested and that 1.5 million UXO items still may exist (Mason and Hanger 1992). In addition, another 7 million inert projectiles having live fuses or spotting charges may be present (U.S. Army 1995b). Because of the historical practices at the installation, UXO may be found anywhere north of the firing line.

3.2.1 North of Firing Line

In general, the ordnance ranges consist of the weapon firing point; the impact zone, a designated area of land where the projectile was expected to impact; recovery areas within the impact zone consisting of areas cleared of vegetation; and a safety zone, a designated area of land surrounding the firing position, flight path, and impact zone. JPG operated up to 125 permanent weapon firing positions and 143 temporary gun positions for a total of 268 gun positions. The majority of the large-caliber weapons were situated to fire north from the firing line. However, weapons also were fired from north to south and from east to west to meet testing requirements (Mason and Hanger 1992; USACE 1995). In 1992, JPG had 50 designated impact zones spread across approximately 8,600 acres (34.8 km^2). Based on interviews

with JPG personnel, impact fields designated for inert munitions also contain HE, UXO, and impact zones, and the immediate surrounding land areas contain large quantities of residual inert metal fragments and munitions parts (Mason and Hanger 1992; USACE 1995).

Munitions tested at JPG varied in size from 20 mm, small-caliber cannon (HE rounds) and improved conventional munitions submunitions (approximately 1 in. in diameter) to 240 mm Howitzer projectiles and 2,000-pound (907-kg) bombs. UXO and residual metal parts are located from the surface to a depth greater than 25 ft (7.6 m) BGS. Figure 1-1, located at the end of this report, shows the occurrence of UXO north of the firing line. The majority of munitions and residue are concentrated at or near the impact zones; however, singular munitions are distributed across a vast area of JPG outside of the impact zones (Mason and Hanger 1992; USACE 1995).

Mason and Hanger (1992) have indicated UXO removal at JPG would present a substantially greater challenge compared to other ranges because of the type and nature of the munitions and extent of the land area contaminated. UXO cleanup would be challenging because of the quantity and diverse types of ordnance evaluated at the installation; the numerous multipurpose range sites geographically situated over the area; the overlap of trajectory paths versus impact/target zones; occurrence of malfunctioning and/or erratic munition performance resulting in an unknown terminal impact location; munition earth penetration into a variety of surface conditions (wooded, grassy, dry, wet, etc.); availability of records; condition of UXO munitions exposed to corrosive elements; and the land area used at different periods for ordnance evaluations (Mason and Hanger 1992).

Based on interviews with installation personnel, the most accurate munition records are available for the DU projectiles (Mason and Hanger 1992; USACE 1995). All firings of DU were conducted from specific gun positions toward the DU impact zone. During active operations of the DU Impact Area, explosives ordnance personnel periodically would sweep the range area surrounding the DU impact zone to recover DU. The recovered projectiles and fragments were weighed and the recovered weights subtracted from the fired projectile weights to determine the total DU material weight remaining in the range. DU projectiles were fired from large-caliber guns at high velocities. Upon impact, the projectiles penetrated into the earth, ricocheted, or broke into two or more pieces in addition to the preceding. DU projectiles would break into chunks rather than shatter into pieces (Mason and Hanger 1992). Firing of DU projectiles against metal target plates, which could contribute to minute particle fragmentation of DU rods and particle burning, was neither authorized by the NRC license nor conducted by the Army at JPG.

The Army currently is deferring an RI/FS of the area north of the firing line due to the physical and personnel safety hazards associated with UXO in this area (SAIC 1997a). Therefore, no intrusive studies have been conducted on the 22 sites identified north of the firing line. The area north of the firing line was subject to routine clearing of vegetation by disc plowing and infrequent herbicide application in addition to detonation of weapons (MWH 2002).

The time frame for an environmental investigation of this area is dependent on regulatory requirements, the level of safety that may be attained during an investigation, the technology available to eliminate potential hazards, and the identification of reuse options and associated cleanup requirements for this area (SAIC 1997a).

3.2.2 South of the Firing Line

Potentially hazardous substances identified at JPG include various explosive compounds, waste propellants, lead, chlorinated solvents, wood preservatives, sulfur, silver, photographic development wastes, sanitary wastes, and petroleum products. Some substances are known to have been released to the soil as a result of waste disposal activities. Subsequently, groundwater also became contaminated. Recent

environmental investigations into the potential contamination at JPG have included site-specific, as well as base-wide, studies. Investigations have focused on the extent of contamination of the soil and groundwater at potentially contaminated sites in the cantonment area. Groundwater studies also have been conducted around the southern cantonment area (SAIC 1997a).

In support of the BRAC process, the Army is implementing an RI/FS of the area south of the firing line. The objective of the RI portion of this study is to define the extent and magnitude of environmental contamination within 50 identified sites (54 locations) and to assess the potential risks to receptors. The Phase I Final Draft RI, which investigated 50 sites, was issued in 1994 (Rust E&I 1994) and followed by additional investigations for 23 of the sites. The Phase II Draft RI, which incorporates the Phase I and Phase II results, was issued in August 1998 (Rust E&I 1998). The Phase II Draft Final RI (MWH 2002) addresses regulatory comments on the Draft RI and incorporates additional work completed since the Draft RI was submitted. The sites for which No Further Action (NFA) was recommended during the Phase I RI (Rust E&I 1994) are not addressed in the Phase II Draft Final RI (MWH 2002)

There are 30 sites addressed in the Phase II RI (23 sites with Phase II sampling and 7 Phase I sites without sampling) [MWH 2002]. For these and other sites where risks are at acceptable levels, technical memoranda will be prepared that recommend NFA, resulting in removal of these sites from the RI/FS process. Table 3-7 identifies the 30 sites evaluated during the Phase II RI and indicates the 15 sites for which NFA is recommended (includes 14 sites which have undergone interim remedial removal actions). Fifteen sites will be assessed in the FS and are summarized in Table 3-8.

Table 3-7. Sites South of the Firing Line Evaluated in the RI

Site No.	Site Name
1	Building 185 Incinerator[c]
2	Sewage Treatment Plant[c]
3	Explosive Burning Area[c]
4	Abandoned Landfill[c]
5	Wood Storage Pile[b]
6	Wood Burning Area[b]
7	**Red Lead Disposal Area**[a,c]
8	**Building 295 Small Arms Firing Range**[a,b]
9	Burning Ground South of Gate 19 Landfill[c]
10	**Gate 19 Landfill**[a,c]
12A	**Building 602 Solvent Pit**[a,c]
12B	**Building 617 Solvent Pit**[a,c]
12C	**Building 279 Solvent Pit**[a,c]
13	Old Fire Training Pit[a,b]
14	**Yellow Sulfur Disposal Area**[a,c]
15	**Burn Area South of New Incinerator**[a,b]
21A	Building 204 Temporary Storage Area[c]
21B	Temporary Methylene Chloride Storage Area[c]
25	**Papermill Road Disposal Area**[a,b]
26	**DRMO Storage Area and Possible Sites South of DRMO**[a,b]
27	Sewage Sludge Application Areas[c]
28	**Gator Z Open Burn Area**[a,b]
29	**Gator Z Mine Scrap Disposal Area**[a,b]
30	Building 204 Pesticide Storage Area[c]
31	Building 227 Former Storage Pad[b]
33	**Building 333 New Incinerator**[a,b]
34	Building 136 Sandblasting Area[b]
38	Northwest-Southeast Runway Flare Test Area[b]
39	Gator Z Mine Test Area[b]
42	Building 281 Indoor Range[b]

Source: MWH 2002.
[a]Bolded sites are those that have had interim remedial removal actions completed by the Army.
[b]Sites for which No Further Action is recommended.
[c]Sites recommended for further evaluation in the Feasibility Study.
RI = Remedial Investigation.

Table 3-8. Feasibility Study Sites Located South of the Firing Line

Site Number and Name	Rationale for Inclusion in the FS	Proposed Solution/Action	COCs
1 – Incinerator (Bldg. 185)	Future residential risks exceed EPA risk-based criteria	Completion of close-out process; restrictions on residential/agricultural land uses	Soil – Dioxins and metals
2/27 – Sewage Treatment Plant and Sludge Application Areas	Chronic health hazards associated with the future residential land use	Restrictions on residential/agricultural land uses	Soil – Aluminum, arsenic, beryllium, chromium, manganese, silver, and thallium Sediments – Aluminum, arsenic, beryllium, chromium, iron, manganese, and vanadium
3/4 – Explosive Burn Area and Abandoned Landfill	Future human health risks and hazards exceeding EPA risk-based criteria	Monitoring of groundwater and crops	Soil – Metals, SVOCs, and dioxins Groundwater – Metals Dust – VOCs and metals
7/21B – Red Lead Disposal Area and Bldg. 211	Future on-site worker and resident health hazard estimates exceed EPA risk-based criteria	Possible additional investigation of arsenic	Soil – Aluminum, barium, beryllium, lead, manganese, and pesticides Groundwater – Arsenic and barium
9/10 – Burning Ground South of Gate 19 Landfill and Gate 19 Landfill	Chronic health hazard estimates exceed EPA risk-based criteria	Additional sampling of several chemicals	Groundwater – metals
12A, 12B, and 12C – Buildings 602, 617, and 279 Solvent Pits	Elevated risks to potential future residents and industrial workers	Natural attenuation and soil venting	Groundwater – 1,1,1-trichloroethane, 1,1-dichloroethylene, and 1,1-dichloroethane
14 – Yellow Sulfur Disposal Area	Presence of UXO, remaining acidic environment, and future potential human health risks	To be determined	Soil – UXO, chromium Groundwater – Arsenic
21A/30 – Temporary Storage Area (Bldg. 204) and Adjacent Shed	Future residential health hazard exceed EPA target range	Additional sampling of subsurface soil and groundwater	Surface soil – Dieldrin

Sources: MWH 2002.
COC = Chemical of concern.
EPA = U.S. Environmental Protection Agency.
FS = Feasibility Study.
SVOC = Semivolatile organic compound.
UXO = Unexploded ordnance.
VOC = Volatile organic compound.

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4.0 PROPOSED ACTION AND ALTERNATIVES

Alternatives that were considered for the JPG DU Impact Area include Alternative 1, termination of the NRC license for restricted release (Proposed Action) [Section 4.1]; Alternative 2, termination of the NRC license to allow unrestricted use (Section 4.2); and Alternative 3, the No Action Alternative (Section 4.3). Section 4.4 discusses alternatives considered but eliminated from detailed analysis. The discussion of the Proposed Action is based on information contained in the DP (U.S. Army 2002b). The discussion of the unrestricted use alternative is based on information in the 1999 DP (U.S. Army 1999) and in Mason and Hanger (1992).

4.1 ALTERNATIVE 1: LICENSE TERMINATION UNDER RESTRICTED CONDITIONS (PROPOSED ACTION)

Under the Proposed Action, the U.S. Army would terminate NRC license SUB-1435 but maintain institutional control of the DU Impact Area. Because of the presence of DU and UXO throughout the licensed area, this area is not suitable for commercial or residential development. Institutional controls would be enforced to restrict access to the DU Impact Area. Under the MOA (U.S. Army 2000), the FWS and the USAF have assigned infrastructure maintenance responsibilities.

The installation would remain fenced with a 6-ft (1.8-m) chain-link fence topped with barbed wire. Approximately 48 miles (77.2 km) of fencing surround the installation. Security warning signs are placed around the property to caution persons not to enter the property. Damaged gates and holes in the fence large enough to permit human access would have to be repaired within 72 hours of being documented (U.S. Army 2002b). The impact area north of the firing line, which contains the DU Impact Area, would remain fenced from the cantonment area. Gates through this fenced area would remain locked, and only authorized access would be allowed. At each location where a stream crosses the fence line, a steel cable would be placed with warning signs attached. All roads approaching the DU area would remain barricaded and marked with a radiation warning sign. On-site personnel entering the DU Impact Area on these roads would be instructed to neither remove nor pass any barricade.

The perimeter fence surrounding the installation would be patrolled and inspected weekly by the USAF. The date of inspection, the name of the inspector, a description, and the location of damage observed would be recorded. All roads approaching the DU Impact Area would remain barricaded and posted with warning signs with the radiation hazard symbol and the words, “Caution, Radioactive Materials.” These radiation warning signs would be posted around the perimeter of the DU Impact Area.

Visitors to the Big Oaks NWR would be required to obtain an annual (or daily) public access permit, attend a safety briefing, and sign an acknowledgment of danger agreement before entering the refuge. Hunting on the refuge would be permitted only in designated areas. The DU Impact Area would remain closed to the public visiting the refuge (FWS 2001a,b).

No environmental monitoring would be conducted.

4.2 ALTERNATIVE 2: LICENSE TERMINATION FOR UNRESTRICTED USE

Under this alternative, a portion of the 2,080-acre (8.4-km^2) DU Impact Area would be remediated to allow unrestricted use of the land. UXO, DU fragments, and DU-contaminated soil would be removed from the DU Impact Area so that the residual dose to the average member of the critical group would be

25 mrem per year or less. Approximately 150 to 1,300 acres (0.6 to 5.3 km^2) of the DU Impact Area would be disturbed to remove DU fragments and contaminated soil. The UXO and DU would be removed using a multi-phase remediation process: manual extraction, radiological survey, and soil treatment. First, a manual extraction process would be used to remove UXO and large DU fragments or complete penetrators to minimize impacts to the ecosystem. Multiple passes could be required to increase the likelihood of finding all UXO and DU penetrators or fragments. Human search rates were estimated to range from approximately one-third to a few acres per person per day (Mason and Hanger 1992). Electronic equipment searches would be conducted using both existing and developing technologies.

After the DU fragments or penetrators were collected, a radiological survey would be conducted to identify the remaining areas of concern. The volume of soil removed depends on the areal extent of remediation and the depth of soil removal. For UXO detection and clearance, the acreage ranges from 150 to 1,300 acres (0.6 to 5.3 km^2) to a depth of 4 to 10 ft (1.2 to 2.0 m). DU survey and removal could involve 150 to 1,300 acres (0.6 to 5.3 km^2) and involve depths of 2 to 4 ft (0.6 to 1.2 m). The range in the estimated soil volume, therefore, is large, approximately 13 to >500 $\times$ 10^6 ft^3 (0.4 to 14 $\times$ 10^6 m) [U.S. Army 2002b]. Under this alternative, not all of the 1,300 acres would be remediated.).

UXO clearance could be required to a depth of 4 to 10 ft (1.2 to 3.0 m) BGS (U.S. Army 2002b). Subsurface cleanup of UXO would depend upon the state of the art in detection and/or cleanup (Mason and Hanger 1992). Cleanup of UXO could be accomplished using either human search lines or different state-of-the-art detection technologies, such as a surface-towed ordnance locator system (STOLS), ground-penetrating radar (GPR), and harmonic radar (Mason and Hanger 1992).

If further remediation is required, several inches to several feet of soil would be removed, and the DU remaining in the soil would be extracted for disposal off-site. Three potential extraction technologies to remove the small, more mobile DU component include bicarbonate soil washing, vacuuming soil into a collection vehicle and packaging it for disposal, and a gravity-based separation of DU fragments from excavated soil (U.S. Army 1999).

The DU metal and DU-contaminated soil would be assayed, packaged, and disposed of off-site. A radiological survey would be conducted to verify that residual DU concentrations meet unrestricted use concentration limits.

No environmental monitoring would be conducted after remediation is completed.

4.3 ALTERNATIVE 3: NO ACTION

Under the No Action alternative, the NRC license would remain in effect in accordance with the requirements of 10 *CFR* Part 40. Licensed material would remain in the DU Impact Area; the environmental monitoring program for soil, sediment, groundwater, and surface water would continue; and the existing site security plan would be implemented to minimize unauthorized entries into the DU Impact Area.

4.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

The alternative of remediating 1,300 acres (5.3 km^2) of the 2,080-acre (8.4-km^2) DU Impact Area to remove DU from the surface and subsurface soil was considered but eliminated from detailed analysis for several reasons. Factors affecting this decision include worker safety, impacts to the environment, and the potential cost.